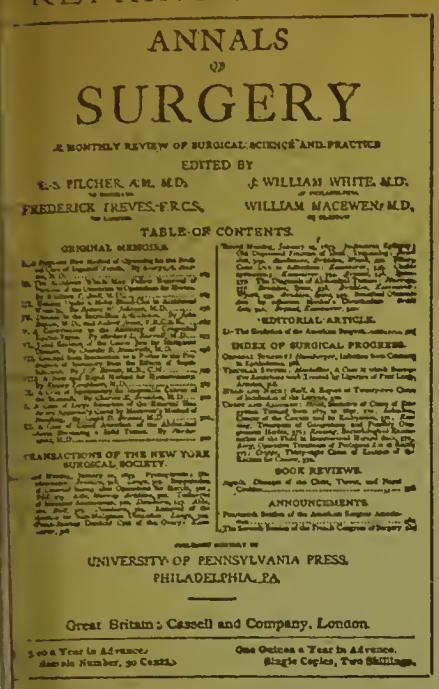
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EDITED BY

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20.

THE QUESTION OF OPERATIVE INTERFERENCE IN RECENT, SIMPLE FRACTURES OF THE PATELLA.

By CHARLES A. POWERS, M.D.,

OF DENVER,

Professor of Surgery in the University of Denver; Surgeon to St. Luke's Hospital and to the Arapahoe County Hospital.

THE QUESTION OF OPERATIVE INTERFERENCE IN RECENT, SIMPLE FRACTURES OF THE PATELLA.



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By CHARLES A. POWERS, M.D.,

OF DENVER,

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It is now twelve years since Dennis made his well-known report on this subject, at the close of which, in recommending open arthrotomy and osseous suture, he said,—

"It will be for the future practice of surgery to pass a final verdict upon this method of treatment of fracture of the patella, after a study of the results obtained in the few years to come. . . . With the gigantic strides which modern surgery is making, it is safe to predict that in careful hands this operation will be devoid of every risk to life."

And recently this distinguished author, while continuing to adhere to operative interference, repeats (Dennis's "System of Surgery," Vol. i, p. 558), "While the number of cases yet operated upon is too limited to admit of deductions by means of which a final settlement of this question can be made in the minds of surgeons, the future practice of the surgery of this and of other countries will soon enable us to condemn it as an unsafe and unjustifiable procedure, or else it will be conceded as one of the grandest triumphs of our art."

It cannot be denied that the statistics of Dennis made but a poor argument in favor of open arthrotomy in recent, simple, transverse fractures. Bull (*New York Medical Record*,

[1] Read at a meeting of the American Surgical Association, New Orleans, April 19, 1898. [2] Dennis's System of Surgery, Vol. i, p. 558.

March 22, 1890), in a consistent article opposing operative measures, said,—

"Of wiring the patella, it is needless to say that, while it made its entrance into practice by the advocacy of the pioneer in antiseptic surgery, Sir Joseph Lister, it has never received general support. . . . It is sufficient to know that death and disaster from amputation and suppuration and ankylosis have followed its performance in the hands of the many, and that we have no evidence that when, in the hands of the few it has proven safe, the ultimate results have been better than those by non-operative methods." The statistics of Brunner and Beck, which appeared at about the time of Dennis's article, also argued against arthrotomy and in favor of simple measures. But the past decade has brought advance in all departments of operative surgery. The field has steadily widened, and the improvements in aseptic technique have led to increased faith in the safety of operative procedure. Operative interference in simple fractures of the patella has increased in frequency rather than diminished. It numbers among its adherents many of the most distinguished of our craft, and it is the object of this inquiry to determine, so far as may be possible, what its true place is and wherein lie its limitations.

In addition to the operative risks which attend any major procedure certain anatomical conditions render the knee-joint an especially important field in the event of septic mischief. It is a synovial membrane wide in area, difficult of thorough cleansing, with many nooks and recesses. Infection once under way may spread with great rapidity. Czerny, in a recent personal communication, says,—

"I do not know why the danger in operations for fractured patella is greater than in many cases of laparotomy, but I feel that it is so." It may be that a rational explanation for this lies in the vastly greater lymphatic drainage which the peritoneum presents. In the highly advanced stage of our aseptic art the risk of infection in open arthrotomy of the knee may be a small factor at this day, but it is a constant

one. The surgeon may be morally certain that his wound will pursue an aseptic course, but he cannot be absolutely sure of this, and, as said, this danger, while slight, will yet be constant. In the consideration of the subject, then, two prominent conditions command our attention; the danger to life and limb and the value of the procedure as evidenced by improved ultimate results. For unless it can be shown that the latter out-weigh the former operation must fall to the ground.

The first of these conditions can at this time be estimated with a fair approach to accuracy. Enough cases are on record to enable us to judge well regarding the danger. But in the matter of ultimate results our conclusions must be in large part inferential, as with but few exceptions the cases have been reported too soon after operation. They are instances of operative recovery, and they permit an expression of the individual opinions of the reporters, but they unfortunately do not warrant judgment as to the definite usefulness of the limb after the lapse of a suitable length of time. We need late reports on large series of cases from individual operators. The cases should be thoroughly tested after a lapse of one or two years, for in no class of fractures does time make greater changes. A patient presenting a good result and a highly promising condition at the end of two months may walk badly, a year later, through stretching of the callus, while gradual muscular improvement may render the converse true. Tests should be made systematically and should be both structural and functional (Myles).

(*a*) *Structural Tests.*—The patella may be examined as to union of the fragments by illumination by the Röntgen rays, by palpation by the fingers when the leg is extended and flexed and when the weight of the body is borne on that limb. Mobility of the patella as a whole is to be inquired into.

The joint is tested for arthritis by passive motion, and the state of the muscles may be a guide to this. Stiffness short of ankylosis and tending to wear off is indicative of a low grade of joint inflammation.

Atrophy of the muscles may be tested by mensuration, by palpation, and by ability to contract under the fingers in response to electrical currents.

(*b*) *Functional Tests.*—Voluntary flexion and extension, ability to ascend and descend stairs, to dance and kneel, to raise the heel while lying on the back, to raise the heel from a high-stool while standing erect on the opposite limb, to spring from the floor and to hop while standing on the affected leg only. Ability to walk ordinary distances without early and unusual fatigue, and to pursue occupation when the latter be difficult.

Enough of these tests should be made to permit of judgment regarding the result after one or two years; but very few of the reported cases bear this examination.

The truest test as to result is the ability to walk long distances, to pursue arduous occupations, to easily ascend and descend stairs, and the like. This, in most instances, depends on preservation or restoration of the quadriceps femoris and absence of arthritis quite as much as on the condition of the patella itself. The union between the patella fragments may be very close and the functional use of the joint poor, while numerous instances are recorded in which the fragments are separated by several inches yet in which the limb is strong and useful. Rupture or preservation of the tendinous expansion of the vasti is of great importance in determining the result in these cases of marked diastasis.

While the union between the patellar fragments is generally spoken of as bony or ligamentous, there are so many recorded instances (Sayre, Stimson, Bogdanik) in which post-mortem examination has proved an apparently bony union to be fibrous that it would seem best to discard the term "bony union" and substitute "complete" and "incomplete." The former to denote failure to obtain independent mobility of the fragments, while an incomplete union may mean a short or a long fibrous callus. True bony callus cannot stretch. While it may occur, it is of such rarity that it need hardly engage our attention. Indeed, Pibræ (Coriton,

"Thèse de Paris," 1892) offered one hundred louis for positive proof of it. It matters not, however, whether the callus be bony or fibrous so long as the fragments be intimately joined and remained so.

Mechanism.—The majority are due to muscular action, the patient endeavoring to save himself from falling, the quadriceps femoris being strongly contracted at the time. While Brunner found but 17 per cent. of tear-fractures in the cases from Bruns's clinic, and while Bähr (*Sammlung klinische Vorträge*, 1894, No. 107) had observed eight cases of direct trauma in a total of twice the number, yet the weight of clinical evidence is much in favor of the preponderance of cases of muscular origin. Aside from the history given by the patient, often untrustworthy, the examination directly after the accident may aid in determining the nature of the injury. Wide separation of the fragments with prolapse of the prepatellar tissues into the breach speaks for a muscular origin. Contusion fractures have less diastasis and less intervening tissue as well as less lateral laceration of the soft parts, hence in these the prognosis is the better. Muscular action rarely causes fracture unless the knee is bent at the time. Here, as Macewen (ANNALS OF SURGERY, Vol. v, p. 181) has shown, the sudden development of the full retractive force of the powerful quadriceps causes the patella to be jerked upward, relatively to the femur, beyond the position where it usually lies supported laterally by the femoral patellar surface. The patella being held below by the powerful ligamentum patellæ rests on the apex of its posterior vertical ridge, which thus becomes the point upon which is developed the greatest contractible power of the quadriceps extensor on the one side and the weight of the body on the other. The patella is thus converted into a lever of the first order, and the strength of this lever not being sufficient to stand the strain, it gives way and the transverse fracture of the patella is the result. Somewhat similar is the mechanism of the contusion fracture when the knee is bent. I think Bähr correct when he says that the blow usually falls on the under half of the patella when the

upper half is lying against the lower end of the femur. Thus the patella is broken off and not through.

With the vertical fractures, as well as with those which are complicated, or with rupture of the tendon of the quadriceps or of the patellar ligament we have nothing to do in this article.

Pathology.—In the fractures due to muscular action there are but two fragments. Of these the upper is generally the larger. The fractured surfaces are, as a rule, irregular, the line of fracture may be transverse or oblique. In the latter event it is apt to run from above and without downward and inward. At times but a shell of bone may be torn from the lower angle of the patella, leaving the bone itself practically intact. In the contusion fractures the lesion may be single or comminuted; not infrequently the latter, the so-called star-shaped fractures. These contusion fractures may be associated with fracture of one or other of the epicondyles of the femur, but this is of rare occurrence. The fractured surfaces are generally fairly even. Chapius and Stoops each found a V-shape in the upper fragment, the lower being correspondingly grooved.

The fragments may lie in a normal plane or they may be turned or twisted. Crickx ("Le Massage et la Suture osseuse dans les Fractures de la Rotule," Bruxelles, 1896) thinks that ordinarily the fractured surfaces are turned towards the skin, and that this is due to the insertion of the rectus and the patellar tendon on the anterior surface of the bone. Howard Marsh found this condition in two out of ten of his recently operated cases, the fractured surface of each fragment looking anteriorly. Roswell Park found the fractured surface to be turned posteriorly in one of his operations.

Of the greatest importance in these fractures are the associated lesions in the capsules of the joint, the lateral tendinous expansions of the vasti, the so-called "ailerons" of the French writers. These tears are often met. Indeed, Crickx says that they are almost invariably present when the diastasis amounts to two centimetres. The femoral

aponeurosis is generally left intact. The prepatellar bursa is torn and the synovial pouch is opened to a greater or less extent. The more extensive the lateral tears in the aponeurosis the greater will be the synovial lesion, and the more complete is this synovial laceration the greater will be the accompanying hæmarthrosis, for more bleeding takes place from the very vascular synovial membrane than from the fractured surfaces themselves.

Riedel, of Jena, lost from chloroform a patient on whom he was operating for recent patella fracture. On continuing his examination he found a tear two centimetres long in the upper part of the synovial pouch beneath the triceps and much extravasated blood beneath the muscles of the thigh. He attributed this tear to energetic contraction of the subcruræus muscle, the tensor of the synovial pouch. Klemm, of Riga, has made a similar observation. Fowler, of Brooklyn, calls attention to this lesion as explaining the extension of suppuration from the knee-joint to the deep parts of the thigh, and other authors claim that blood thus extravasated may by pressure and organization lead to or add to atrophy of the thigh muscles.

Hæmorrhage into the joint is always marked; it is more extensive in the muscular fractures and in those in which the fragments are widely separated, for, as said, in these cases the synovial membrane is more seriously lacerated. The organization of the clots leads to adhesions and arthritis.

The prepatellar tissues fall into the breach. This is a matter of the greatest importance. First described by Macewen, later studied in detail by Hoffa, and since confirmed by almost all observers who have operated, there is now no room for doubt that the prolapse of the floor of the bursa and the aponeurotic fibres at the front of the patella is of constant occurrence in all cases of fracture due to muscular action, while Phelps and other writers state that it is almost invariably found in breaks due to direct violence.

Conditions tending to cause Imperfect Union: Obstacles to Union.—In seeking these we can most properly judge regard-

ing measures which are calculated to attain the best possible results, for that ordinary results after fractured patella are far from perfect is admitted by all. These conditions may be enumerated as follows:

(1) Separation of fragments: due to (*a*) retraction of the upper fragment from contraction of the quadriceps femoris and a slight drawing down of the lower fragment through shortening of the ligamentum patellæ; (*b*) effused blood.

(2) Tilting of the fragments (this may be present to a marked degree and unrecognizable without operation).

(3) Rupture of the tendinous expansion of the vasti and of the lateral portions of the capsule of the joint.

(4) Prolapse of prepatellar tissues into the breach.

(5) Atrophy of the quadriceps femoris: due to (*a*) disuse; (*b*) arthritis; (*c*) marked contusion of the muscle; (*d*) blood extravasated from the joint through the rent in the upper part of the capsule.

(6) Arthritis of the knee-joint, this possibly resulting in

(7) Adhesions of the patella. Further, though of but little value, may be added

(8) Natural poverty of the blood-supply to the bone (rendered negative by the fact that vertical fractures heal satisfactorily), and

(9) Exceptional tendency to osteitis, seen in fat people, in the aged, and in certain conditions of the blood.

These factors may, perhaps, best receive consideration as we discuss the management of the fracture.

Non-Operative Management.—No better evidence of the unsatisfactory results attending treatment of fractured patella by mechanical means need be adduced than the great variety of plans and devices which have been set forth from time to time. Berger ("Dictionnaire encyclopédique de Médecine;" Coriton, *Gazette des Hôpitaux*, 1892, lxv, p. 1349) has reckoned up no fewer than ninety-one different methods, and in the literature of more recent date I easily find enough to make the number over one hundred. It will suffice at this

place to call attention to but three or four of these. First and best known, the general plan of making the closest possible approximation of the fragments, after subsidence of the joint swelling, by properly applied bandages or strips of sticking-plaster, and then confining the limb on a splint or in a plaster-of-Paris dressing. Of the various posterior splints Agnew's is perhaps as suitable as any. In approximating the fragments care is taken to see that they tilt as little as possible.

Millar, of Edinburgh, thought that the interposed aponeurotic tissues could be removed by friction, but this is improbable. Bony crepitus may indicate contact at one point only. Early aspiration of the joint effusion may succeed if done before the blood clots, but this clotting takes place early, and after it occurs the joint can only be emptied by a broad trocar and canula. This, with or without irrigation, may well be thought almost as serious a procedure as open operation.

The use of Malgaigne's hooks, or of the modifications by Levis or Otis or Duplay, as an aid to coaptation seems to have declined. Treves speaks well of them, and they are still used to a moderate extent in France. I have seen but little of the method, but do not judge that they give results superior to simple dressings.

The most valuable of the non-operative forms of management I take to be that of massage, the so-called "Dutch" method. Introduced by Tilanus, of Amsterdam, in 1885, this measure has had extensive trial, and all who have employed it speak well of it. A brief description is as follows: During the first twenty-four or forty-eight hours the limb is elevated and the joint compressed by an elastic bandage. On the second or third day the massage is commenced, and should be carried out by the medical attendant himself. The upper fragment is fixed by the fingers of one hand, while with the other gentle massage is made from the knee along the thigh muscles. If an assistant steadies the fragments both of the surgeon's hands can be used in this. Effleurage or stroking of the knee is made; the muscles are to be kneaded. The

leg should also receive attention. At first the *séances* should be from eight to fifteen minutes in length, but the time may be increased as the days go by. The massage should be made twice daily; it will provoke pain in the early days, but this rapidly subsides. The degree of pain will perhaps govern the amount of the massage at first, but after a few trials the patient will experience a sense of comfort and relief. Between the massage *séances* the fragments are held in apposition by straps of plaster, and the limb is so elevated that the extensors of the thigh are relaxed and the return circulation favored. Passive motion is begun very early; it prevents adhesions, both intra-articular and between the torn or bulging synovial membranes and the capsule of the joint, as well as between the soft parts and the condyles of the femur. This passive motion should be progressive, but should not be carried to the point of causing marked pain. Further, the patient should be up and about on crutches early,—by the eighth or tenth day. Two weeks later he discards the crutches and walks with two canes, later still with but one cane. In the average case the joint effusion will have disappeared by the end of the third week, and at this time the patient will be able to flex the leg to 135 degrees. By the fortieth day he will walk quite well. He is to wear a suitable check apparatus (one of the best of which has recently been described by Howard Marsh in the *British Medical Journal*) until flexion is beyond a right angle.

So far as the immediate results go it is not difficult to see that the Dutch method is superior to other non-operative procedures, and while, as I have said, observers have generally reported their cases at too early a day, I am inclined to think that the remote results surpass those attained by the older methods.

Ham ("De Voor en Nadeclen van de Behandlung," etc., Amsterdam, 1893) reports twenty-one cases, a majority of which had been observed for one year. While it is difficult to get at the exact results, it is evident that nearly all had complete and strong extension, and flexion almost equal to

that on the opposite side. In five out of the twenty-one cases there was complete union of the fragments, a percentage which is certainly above that attained by confinement methods.

Zum Busch (*Centralblatt für Chirurgie*, 1895, p. 449) reports on eleven cases treated by the method of Tilanus. He let his patients get up and go about in a simple splint with a cane on the second day; all returned to work at the end of six weeks, at which time each could lift the leg from a high-stool while standing on the opposite foot. The author does not give the amount of separation of the fragments nor the degree of flexion of the leg, but it must be admitted that the work test is a satisfactory one and the results exceedingly good. I find reports of numerous individual cases which confirm the value of the massage treatment (faradism to the muscles may be an adjuvant in this), and can make no doubt that it is the most satisfactory and valuable of the non-operative methods of management. Aside from this I can find no statistics as good as those of Bull, who reports (*New York Medical Record*, March 22, 1890) on sixteen cases of recent fracture treated by plaster-of-Paris splint with appropriate confinement of the fragments, and observed by him at periods varying from one year and nine months to thirteen years after the date of the injury. Of these sixteen cases the ultimate result was excellent in fourteen, or 87½ per cent., and bad in two cases, or 12½ per cent., of the whole. A review of Bull's cases seems to show but four in which the cause was clearly muscular action. The patients, for the most part, pursued arduous occupations after the injury. One was a metropolitan policeman, two were firemen, two truck-drivers, two laborers, two housekeepers, one a waiter. This form of treatment involves confinement for about six weeks, at the end of which time the patient can resume any amusement or occupation that can be carried on with a knee stiffened with a ham-splint. During the following three months much care must be exercised to prevent accidents. Without citing further references, it may, perhaps, suffice for me to repeat

that while the massage treatment entails arduous work on the part of the surgeon a careful study of the subject convinces me that it yields the best results of any of the non-operative forms of management. Crickx, in an extended argument in favor of open suture, compares this only with massage, which latter method he takes as the type of the simpler forms of treatment.

Operative Treatment.—So far as I am able to learn, the first operations for the cure of fractured patella were made by Rhea Barton and by McClellan, of Philadelphia. These were followed by Cooper, of San Francisco, in 1861, and afterwards by Logan, Gunn, Cabot, Kuhne, Abridge, and Heine. The results varied, but were on the whole far from encouraging, septic processes being rife in all open wounds of this preantiseptic day. It was, therefore, reserved for Lister to deliberately place the operation on a plane commanding attention and respect. This renowned surgeon, with faith in his theory and practice of antisepsis, sutured a fractured olecranon in 1873, and at this time proposed to do the same with broken patellæ, but it was not until 1877 that he carried out this resolve, at this time submitting a freshly broken knee-cap to open arthrotomy and suture, the result being a marked success. In 1883 he presented seven cured cases to the London Clinical Society and argued in favor of the procedure. The operation was essayed by other surgeons, but the risk attending it was acknowledged to be great, and it found but little favor. From time to time cases were exhibited and the question was warmly argued for and against. Many modifications of the open arthrotomy of Lister were devised with a view to avoiding the dangers of sepsis, some of these sought to bring the fragments in contact without opening the joint.

In this country early, consistent, and progressive work was done at Bellevue Hospital in New York, and to Dennis, Stimson, Phelps, Fluhrer, and the other surgeons of that institution is due, in large measure, the advance in favor which the operation has made.

In estimating the place which it occupies in surgery to-day I have felt it of very great advantage to gain the personal opinions of a certain number of surgeons. With this in view letters of inquiry were addressed to the active and honorary fellows of this association, to the members of the New York Surgical Society, and of the Philadelphia Academy of Surgery, these being purely surgical bodies.[1]

The queries embraced the general question as to advisability of operating on recent, simple fractures, the form of operation preferred, the number of cases operated, with results, and the time at which, in average cases, patients could resume daily life either with or without operation. To these letters of inquiry ninety answers were received, and I beg at this time to express my gratitude to those who so kindly replied. The consensus of opinion therein expressed certainly represents fairly the judgment of the surgeons of our country.[2]

The following say that they have had insufficient experience in the matter and thus refrain from expressing an opinion: D. P. Allen, E. H. Bradford, J. H. Brinton, P. S. Conner, N. P. Dandridge, J. McF. Gaston, C. L. Gibson, Reginald Harrison, W. W. Keen, Willy Meyer, G. H. Monks, E. M. Moore, J. H. Packard, J. Paget, and P. Syms, while L. B. Bangs, G. E. Shoemaker, H. A. Wilson, and V. P. Gibney have worked for some years in other directions than that of general surgery, and so decline to render judgment.

The remainder, seventy-one in number, make the following statements:

Robert Abbe would operate only when there is wide separation of the fragments with probable future displacement. In operating prefers vertical incision, removal of interposed structures, circular patellar suture of heavy silk. Insists on operative

[1] To these have been added the names of Drs. Phelps and Fluhrer, of New York, because of their well-known experience in the matter.

[2] While the answers are not reproduced in full, no important statements are omitted.

removal of interposed fibrous structure. Has operated three times with excellent results. Thinks that general practitioners and most surgeons should refrain from operating. Patients resume daily life in about three months with or without operation.

O. H. ALLIS would operate in cases in which there is comminution with hæmorrhage into the joint, also in single fractures with wide separation of the fragments. Would do open arthrotomy. Would not operate in simple cases without much separation of fragments. Patients return to work in non-operated cases in about two months.

JOHN ASHHURST, JR., does not consider the operation justifiable.

J. M. BARTON operates in cases due to muscular contraction. Open arthrotomy and silver wire. Two successful cases. "Would operate whenever aseptic conditions are within reach." Operated cases resume daily life a little the earlier.

R. B. BONTECOU has operated on three cases,—two satisfactorily, one (comminuted) died from sepsis. In general prefers Malgaigne's hooks.

C. K. BRIDDON would operate only in cases in which the distention of the joint interferes with a reasonable approximation of the surfaces. Prefers vertical incision with free exposure, suture by heavy, chromicized catgut or silver wire. Has operated on two cases with satisfactory results. If massage is used patients resume daily life in from six to eight weeks, there being but little difference between non-operated cases and those submitted to operation.

F. TILDEN BROWN does not approve of operative interference.

J. D. BRYANT has operated on nineteen cases; one died of delirium tremens a few days after the operation. "The others had limbs which, at the time of the escape from observation, were in all ways progressing to a favorable and complete termination, which bespoke a useful joint." Does not believe in operation as a general measure.

H. L. BURRELL would operate in cases in which the fragments cannot be approximated or in those in which the patella has been the seat of multiple fractures. Prefers open arthrotomy by longitudinal incision with two or three buried wire sutures. Has operated on three cases with satisfactory results. Patients

resume daily life in six months to a year in non-operated cases, and in six months in those submitted to operation.

A. T. CABOT refers to *Boston Medical and Surgical Journal*, November 19, 1891, in which he says: "It is the writer's feeling that in simple fractures of the patella the added risks of an opening into the joint are so great that the best treatment is by apparatus."

W. H. CARMALT employs subcutaneous suture with silkworm gut in cases in which the fragments are not easily brought into close apposition. He has operated on four cases with satisfactory results. Non-operated cases return to work in three months, and operated cases in six weeks.

N. B. CARSON has operated in one case with resulting partial ankylosis. Would operate on selected cases.

D. W. CHEEVER does not believe it wise to resort to operative interference in any case of recent, simple fracture of the patella, and thinks the results of non-operative treatment in ordinary cases sufficiently good to warrant a continuance of this form of management. The non-operated cases resume daily life in about three months, patients wearing a guard splint.

JOHN CHIENE does not operate. Gets excellent results from sticking-plaster suitably applied.

H. W. CUSHING has never resorted to operation, but would do so in case the patient requested it after the facts had been fully explained to him. Prefers vertical incision, irrigation of joint, accurate suture of fragments, and their coverings by silk or silver wire. In non-operated cases patients resume daily life in about eight weeks with support, and in from eight months to one year without support.

V. CZERNY does not believe it wise to operate in recent, simple fractures, because the risk of inflammation and ankylosis is too great. Does not know why the danger of inflammation in operations for fracture of patella is greater than in many cases of laparotomy, but feels that it is so. Form of operation, open suture by silver wire. Has operated on one or two cases with resulting inflammation and ankylosis. Believes that with a separation of two to four centimetres the use of the limb is generally sufficiently good. Non-operated cases return to work in from two to six months.

C. W. DULLES: "I do not think, taking advantages and

risks together, that operation is wise. I think that one death or ruined joint in a hundred would determine this,—and we have absolutely no statistics that we can trust to show how many operations have ended disastrously." Non-operated cases resume daily life in about three months.

G. G. DAVIS would operate in all cases in which the fragments cannot be brought almost or quite in contact by simple pressure. Has operated with satisfactory results in about six cases. Non-operated cases resume daily life at the end of two months, but wear protective apparatus for a year. Operative management shortens the treatment, the wire allows use of bone by preventing refracture. Passive motion is safe as soon as the wound is soundly healed, say, at the end of three or four weeks. The joint limbers up sooner and the patient can resume work safely without apparatus.

J. B. DEAVER employs posterior splint (Agnew) with adhesive straps where fragments easily fall together. In case they do not well appose he uses Malgaigne's hooks.

F. S. DENNIS operates when the patient is perfectly healthy, when separation of fragments is wide, when time is of great importance, when both patellæ are fractured; uses silver-wire suture. Has operated on thirty cases; satisfactory results in twenty-nine. Believes the cases for wiring should be very carefully selected; the viscera should be healthy and absolute asepsis is imperative.

W. F. FLUHRER would operate in all cases in which no contraindication exists. Uses silk or catgut suture, but would be prepared to employ silver wire if necessary. Drills fragments and approximates, after thoroughly washing out the joint. Does not consider results in non-operative cases sufficiently good. Has operated on thirty cases with satisfactory results.

G. R. FOWLER would operate when fracture is due to indirect violence with a decided separation of the fragments. The operation should be intermediate, after subsidence of the primary coincident effects of the injury on the soft parts and before ligamentous union has taken place, or as a secondary operation; never as a primary operation. Employs open arthrotomy with suture of capsule when fragments can easily be apposed; otherwise suture fragments with aseptic kangaroo tendon. Has operated on thirty-eight cases; satisfactory results in thirty, suppura-

tion in seven, death in one. It should be said of the seven suppurative cases that six occurred in patients in whom the operation was performed as a primary procedure. There were thirteen of these primary operations, therefore suppuration occurred in nearly 50 per cent. Of the twenty-five intermediate or secondary operations, infection occurred in but one, and in this was traced to the catgut. Non-operated cases resume work in six weeks, those submitted to operation in eight and one-half weeks.

B. B. GALLAUDET operates in all cases in which there is a separation of the fragments to the extent of one-quarter of an inch or more. Employs curved incision and wiring. Has operated in seven cases; satisfactory results in six, suppuration in one. Patients return to work in three or four weeks in non-operated cases, and in about eight weeks in those submitted to operation.

G. W. GAY would operate in young or middle-aged patients who are in good health and obliged to earn a living. Prefers open arthrotomy and wire suture. Has operated on several cases with satisfactory results. Both non-operated cases and those submitted to operation resume daily life at the end of three or four months. "I give you my conclusions based upon a moderate experience and a larger observation. It is not proved to my satisfaction that the operative cases are ultimately any better off than are those not subjected to operation. There are good and bad results from both methods of treatment. It is a safe operation, and the immediate result is first class in the large majority of cases, even if there be some suppuration, though I have never had infection. I have seen the fragments pulled apart at the end of four months, and the fracture do well under a second wiring."

A. G. GERSTER believes operation is rarely needed. He has employed simple suture with stout catgut in three (satisfactory) cases. Non-operated cases resume daily life in six weeks, those subjected to operation in two months.

C. GUSSENBAUER has treated twenty-five to thirty cases of patella fracture. Four times has made suture; in the other cases uses what he calls "dry, not bloody, suture" with good results. Has always considered the open operation indicated only in comminuted fractures with much separation of the fragments.

W. S. HALSTED operates on all of his own cases. Perfect result in fifteen. No suppuration; no drainage. In the hands

of competent surgeons operation yields the best results. Only those sure of asepsis should operate.

R. H. HARTE prefers Malgaigne's hooks when any form of operative interference is necessary. Would use them when the fragments cannot be well approximated without.

F. HARTLEY operates in cases in which the fragments cannot be well apposed by straps. Open arthrotomy, catgut suture of fragments and aponeurosis of vasti. He has operated on twenty-seven cases. Twenty-three were satisfactory, in the other four cases the adhesions were so marked as to render the results unsatisfactory. Under either form of management patients resume daily life in from six to eight weeks.

J. HOMANS uses silk suture to fascia and periosteum. Satisfactory result in two cases. In the average case non-operative treatment is sufficiently satisfactory. Both operated and non-operated cases resume work in about three months.

W. BARTON HOPKINS obtains such good results from a special (ANNALS OF SURGERY, 1895, p. 682) appliance that he is less and less inclined to operate. Might operate in young, healthy subjects with wide (one and a half inches) diastasis. Non-operated cases resume work in about three months.

VICTOR HORSLEY would wire in every case unless there are especial contraindications. Has operated in a number of cases. Suppuration in one, acute, gouty bursitis patellæ in one, wire caused irritation, and had to be removed in one case. Does not treat any cases without operation. Patients return to work in about six weeks.

O. HORWITZ would operate in cases in which the fragments cannot be apposed. Prefers Barker's operation with subcutaneous suture, but in comminution would do open arthrotomy, uniting fragments with silver wire. He has operated in eight cases with satisfactory results. In five by Barker's method, and in three by open arthrotomy. In one case a silver wire suture ulcerated through the skin five months after operation. Patients resume daily life in from eight to ten weeks in non-operated cases, and in about the same length of time in those submitted to operation.

RALPH H. ISHAM does not operate in any case. Non-operated patients resume daily life in about three months.

T. KOCHER operates in all cases in which the fracture is

transverse, with diastasis by laceration of the capsule on both sides of the patella. He has operated on twenty-four cases; satisfactory results in twenty-two, suppuration and stiffness in one, death in one. Employs longitudinal incision with direct suture of the fragments or of the soft parts. Operated cases resume daily life much sooner than those not subjected to operation. "I think it quite essential that the distinction should be made between cases with and without diastasis,—that is, with largely torn soft parts and with more or less intact fascia and capsule. Where there is no diastasis, the best plan is massage with or without puncture of the joint. Where there is great diastasis, I think actually we should always perform the operation, as the time is over when there was a risk of infection and its consequences. My cases of suppuration, stiffness, and death are of the first I operated upon long ago."

L. C. LANE would operate in all cases in which the fragments are extensively separated. Prefers open arthrotomy by transverse incision, removal of clots, trimming off of ligamentous shreds, suture of fragments by kangaroo tendon. Has operated in three cases with satisfactory results. In one of these there was slight extra-articular suppuration under one portion of the flap. In all of his cases treated by non-operated methods many months were required to reach moderate restoration of function, while in those submitted to operation the use of the joint was regained much earlier.

R. G. LE CONTE would resort to open arthrotomy and wiring when the joint is greatly distended with blood and the fragments cannot be brought together. Non-operated cases resume daily life in from ten to twelve weeks.

H. LILIENTHAL prefers the Dutch method of massage. "An office or quiet in-door occupation can be followed during treatment. Functional results perfect, even to hopping on the injured leg. Cure in six weeks. Treatment requires daily supervision and work by surgeon himself." Has operated on one case; satisfactory result.

LORD LISTER: "I may say that operative interference in recent, transverse fracture of the patella was in my hands uniformly satisfactory in its results, and that in my opinion it should always be resorted to, provided always that the surgeon can

reckon with confidence on the wound following an aseptic course."

A. J. McCosh would operate in (*a*) cases in which it is impossible to approximate the fragments within one-third inch of each other; (*b*) in cases of repeated fracture of the same patella; (*c*) in those in which bony union is especially desirable on account of the occupation of the patient. He unites the fragments with suture of chromicized catgut or silver wire, and has operated in two cases with satisfactory results.

T. A. McGraw has never operated on cases of recent, simple fracture, and thinks the cases requiring operation very rare. In such cases would prefer silver-wire suture. Non-operated cases resume daily life in about three months.

C. H. Mastin has had very good results follow ordinary management, and has not met a case which, in his opinion, required operative procedure.

S. Marks does not recommend operative interference in any case of recent, simple fracture of the patella. In non-operated cases patients resume daily life in from eight to twelve weeks.

J. Ewing Mears: "Regarding the patella as a sesamoid bone, I regard its fracture as incidental to a rupture of the important ligament in the folds of which it is embraced, and therefore believe that the ligament should be the important structure to be treated, and attempts to secure union between the fragments of the bone to be regarded as of secondary importance. Having observed that the disability in a large number of cases of non-union and of separation to a greater or less extent of the fragments was not very great, I have even advocated in some instances the removal of the fragments and the suturing of the divided ends of the ligament. I dwell particularly upon the marked difference in the symptoms and conditions following fracture of the patella when it occurs, on the one hand, as the result of muscular contraction and, on the other hand, as the result of violence or force applied directly. In the first instance there is rupture, tearing, and stretching of the fibres of the ligament, thus producing the separation of the fragments of the bone, which at the same time yields to the force which separated the structure of the ligament. In the second, where the force is applied directly, the bone encased in the ligament may be fractured, the fibres of the ligament contused but not ruptured or stretched,

and as a result of these conditions there is no separation of the fragments. I think we may correctly conclude from these facts that the ligament is the essential factor or agent, and that the bone plays a secondary part. Hence I believe that the expression 'fracture of the patella' may be abandoned or removed from surgical nomenclature. Hence, also, I believe that treatment should be applied to very strong and firm suturing of the ligament, as well as the wiring of the bone if it is allowed to remain *in situ*.

"In treating fractures of the patella, so called, by the older methods, I have insisted upon rest in bed and with plaster and splint applications for a period of three months, and have also insisted on non-use of the limb for a period of three months after getting up from bed. By this treatment I have gotten very firm union of the lacerated fibres or bone, I care not which. I have found that this treatment gave good permanent results." Number of cases operated not given, all said to be satisfactory.

J. E. MOORE operates in healthy subjects who desire it after the entire matter has been explained. Employs open arthrotomy with wiring. He has operated in five cases with satisfactory results. Operated cases resume daily life in six weeks, non-operated in three months.

T. G. MORTON would operate whenever it is impossible to bring the fragments in close apposition. Uses heavy catgut suture. Has operated on a number of cases without trouble; thinks there is no danger in the procedure. Patients resume work in about three months with or without operation.

F. W. MURRAY is content with simple forms of management and decidedly opposed to operative procedures.

C. B. NANCREDE would operate only in cases in which the opposite patella had been fractured, the patient young, and the operation managed by an expert in asepsis. Non-operated cases resume daily life in about three months.

J. E. OWENS has operated on all cases during the past five years. He has operated on six cases,—suppuration in one, death in one. Both of these latter cases had multiple injuries. "I have operated of late because of the trouble experienced in consequence of portions of the capsule dipping down between the fragments and preventing union."

J. H. PACKARD has had no experience with operative meas-

ures; has always obtained excellent ultimate results from the use of ordinary non-operative methods or from Malgaigne's hooks. Does not condemn operative management if thoroughly aseptic.

Roswell Park would use wire suture and would operate in healthy subjects, providing the surroundings were satisfactory. Does not consider non-operative management satisfactory. He has operated on ten cases with good result in each. Operated cases resume daily life in eight weeks, non-operated cases in from fourteen to sixteen weeks.

C. Phelps would operate in all cases in which there is no general contraindication. He has operated on 104 cases with satisfactory result in ninety-eight, superficial suppuration with more or less false ankylosis in six. Says he has had bony union in all cases. Washes joint out thoroughly, and considers operation absolutely safe with proper aseptic precautions.

L. S. Pilcher would operate in all transverse fractures when the patient can be treated in a hospital with well organized aseptic operating facilities. Prefers longitudinal incision with trimming away of fibrous fringes and approximation of fragments by chromic gut suture to aponeurosis of capsule. He has operated with satisfactory result in fifteen cases. Does not think the results of non-operative treatment sufficiently satisfactory when requisite experience and facilities for aseptic operative work can be secured. In non-operated cases patients resume daily life in about twelve weeks, in those submitted to operation in from four to six weeks.

C. B. Porter is convinced that wiring shortens the period of convalescence by two-thirds. He has operated on seven cases; very satisfactory result in each. Operation should be done only by a skilled surgeon.

T. G. Porter operates in no instance. Non-operated cases resume work in from four to six weeks.

T. F. Prewitt has never met with a case of recent, simple fracture in which he thought it advisable to operate. Removes splint in three months, and enjoins caution in use of limb until the end of six months.

J. Ransohoff would not operate in the vast majority of cases. Extensive hæmorrhage into joint might justify operation.

M. H. RICHARDSON has not operated in recent cases. Thinks the result in the average case to be sufficiently satisfactory without operation. Patients resume daily life in six months in non-operated cases, and does not think that operated cases should return to work much earlier. Intends to operate on future cases in which the separation of fragments is wide.

J. B. ROBERTS would operate on all cases in which the separation of fragments is not easily overcome by pressure straps of adhesive plaster. Prefers Levis's modification of Malgaigne's hooks. He has never resorted to open arthrotomy in recent, simple fractures. Thinks patients return to work in from six to eight weeks with the knee-joint extended in non-operative cases, and probably a little earlier in those in which the hooks are used.

L. A. STIMSON would operate in practically all cases in which skilled assistance can be had. The exceptions are recent fractures by direct violence (comminuted and without separation of fragments), and in some cases in which the separation is but slight. Prefers longitudinal incision with mediate suture through tendon of quadriceps and ligamentum patellæ crossing in front of bone, or suture of fibroperiosteum at seat of fracture. He has operated on seventy cases with satisfactory result in each. Does not advise operative interference except with the aid of trained assistants and under most rigid aseptic conditions. In the operations done by him nothing but instruments touch the wound, thereby the risk of inflammation is less. In cases submitted to operation patients get about in plaster splint after ten days, wear it for about a month, and return to hard work on the feet at the end of two or three months. Now uses catgut as periosteal suture. "As to ultimate results, I have seen but few patients after the third month; at that time all could, with one exception, flex to a right angle. Some, at a much later date, had full flexion. A few have come back with refracture from forced flexion while the joint was still stiff."

N. SENN does not advise operation in recent, uncomplicated cases.

L. M. TIFFANY operates when the fragments are widely separated and when there is much distention from joint extravasation. Selects healthy subjects of suitable age. Uses longitudinal incision, with suture of fibrous capsule and wiring of

bone if necessary. Has operated in four instances with satisfactory results. Would not operate in ordinary cases. Thinks patients can return to work rather earlier when subjected to operation.

W. W. VAN ARSDALE "would operate in healthy, strong individuals under forty years. Operation, open incision, Fluhrer's drill, two silver wires not penetrating the joint." One case, satisfactory result. Patients able to resume work in eight weeks with operation, three months with massage, and one year with splints only. Believes refracture to take place quite as readily after operation as in cases treated by massage or splints.

A. VANDER VEER believes non-operative methods sufficiently satisfactory in average cases. Has had no experience with operative methods. Patients resume daily life in seven or eight weeks under either form of management.

J. C. WARREN does not think the results of non-operative management sufficiently good in average cases. Applies animal suture to periosteum and fascia. Has operated in three cases with satisfactory results. Non-operated cases resume daily life in about six months, those submitted to operation in about three months. Has used wire suture with satisfactory result, but, as said, prefers animal suture of periosteum and fascia.

F. S. WATSON would operate in cases in which there is but little or no comminution, in those in which neither the upper nor the lower fragment is so small as to make it impossible for sutures to hold, and in cases in which there is evidence of considerable effusion of blood into the joint. Has operated in two cases with satisfactory result in each. In non-operated cases patients resume daily life in from three to four months, while in those submitted to operation six weeks to two and one-half months suffices.

S. H. WEEKS would not operate in any case of recent, simple fracture. In non-operated cases patients resume daily life in about three months.

R. F. WEIR does not think it proper to operate in any case.

H. R. WHARTON operates only in exceptional cases, uses heavy silver wire. In average case non-operative management is satisfactory. Patients resume work in eight weeks without operation, a little sooner with operation.

J. W. WHITE operates in all cases in which there is separa-

tion of the fragments. Employs Barker's operation, and has had satisfactory results in fifteen cases. Operated cases return to work in three to four weeks, non-operated cases in from eight to twelve weeks.

G. WOOLSEY operates in cases with wide separation of fragments and those in which massage and elastic compression do not satisfactorily reduce the effusion and allow the approximation of the fragments in a reasonable length of time. Applies absorbable suture to fibrous tissues at edges of fragments. Has operated on four cases with satisfactory results. In average cases massage and passive motion from the start give excellent results. Non-operated cases treated by massage and passive motion return to work in five or six weeks, and cases submitted to operation do not regain functions as rapidly. His non-operated cases get either bony union or such a close fibrous union that it is impossible to distinguish.

J. A. WYETH is not an advocate of open arthrotomy in any case of recent, simple fracture, but might consider the propriety of it in certain rare instances, where the individual must of necessity have restoration of function within two or three months after the accident. In ordinary cases non-operative management requires about eighteen months of careful guarding of the knee from over-flexion, before there is complete and safe restoration of function. After two or three weeks' confinement to bed patients are allowed to go about with a protective splint.

NOTE.—Since the preparation of this paper I have received a reply from Dr. J. D. Rushmore, of Brooklyn, in which he expresses a preference for Malgaigne's hooks; from Dr. R. Matas, of New Orleans, who operates in selected cases; from Professor Max Schede, of Bonn, who does not resort to open operation; and from Dr. F. Kammerer, of New York, who would operate in exceptional instances.

Summary.—The following would use Malgaigne's hooks in suitable cases where the fragments cannot easily be approximated: R. B. Bontecou, J. B. Deaver, R. H. Harte, and J B. Roberts.—(4.)

The following express themselves as opposed to operation in any case: J. Ashhurst, Jr., F. T. Brown, A. T. Cabot, D. W. Cheever, J. Chiene, V. Czerny, C. W. Dulles, R. H.

Isham, H. Lilienthal, C. H. Mastin, S. Marks, F. W. Murray, T. G. Porter, T. F. Prewitt, N. Senn, S. H. Weeks, and R. F. Weir.—(17.)

The following would operate in all cases in which no distinct contraindication exists and in which the surroundings are satisfactory: W. F. Fluhrer, W. S. Halsted, Victor Horsley, T. Kocher, Lord Lister, J. E. Owens (practically), Roswell Park, C. Phelps, and L. S. Pilcher.—(9.)

The following would operate on selected cases, those with wide diastasis, comminution, etc.: Robert Abbe, O. H. Allis, J. M. Barton, C. K. Briddon, J. D. Bryant, H. L. Burrell, W. H. Carmalt, N. B. Carson, H. W. Cushing, G. G. Davis, F. S. Dennis, G. R. Fowler, B. B. Gallaudet, G. W. Gay, A. G. Gerster (rarely), C. Gussenbauer (rarely), F. Hartley, J. Homans, W. Barton Hopkins (rarely), O. Horwitz (Barker's operation), L. C. Lane, R. G. Le Conte, A. J. McCosh, T. A. McGraw (rarely), J. Ewing Mears, J. E. Moore, T. G. Morton, C. B. Nancrede (rarely), C. B. Porter, J. Ransohoff (rarely), M. H. Richardson, L. A. Stimson, L. M. Tiffany, W. W. Van Arsdale, A. Vander Veer (rarely), J. C. Warren, F. S. Watson, H. R. Wharton (rarely), J. W. White (Barker's operation), G. Woolsey, and J. A. Wyeth (rarely). —(41.)

Analysis.—Analysis of these opinions on the general ground of the advisability or non-advisability of operation would show seventeen, or $23\frac{67}{71}$ per cent., as deliberately opposed to it, nine, or $13\frac{17}{71}$ per cent., as urging it in all cases, in which competent surgical skill can be rendered amid suitable surroundings, and forty-one, or $56\frac{35}{71}$ per cent., as recommending arthrotomy and suture in selected cases, such as those having wide diastasis, comminution, extensive joint distention, etc., while four, or $5\frac{45}{71}$ per cent., favor the use of Malgaigne's hooks. Of the total number, then, over 70 per cent. favor operation in some cases. A procedure which numbers so many supporters must certainly be said to have an established place in surgery, and we may therefore proceed

to the consideration of its dangers, limitations, methods, and results.

Dangers.—In addition to the general risks attending any operative procedure of this nature, the danger from anæsthesia, bronchitis, pneumonia, nephritis, and the like, we have the risk of sepsis from infectious arthritis. In order to estimate as accurately as possible the mortality, I lay before you tables showing the cases which I have been able to gather since the publication of Dennis's paper. These number 711, of which 474 came to me in personal communications, while 237 are collected from published papers.

Those personally communicated represent accurately the work of the surgeons who have favored me with them, and must be acknowledged as presenting valuable statistics. The cases gathered from literature are all to which I have been able to gain access. This latter table is doubtless incomplete, but much effort has been made to render it accurate, and it is thought that no cases have been duplicated. For purpose of comparison the operations for recent, simple fracture have been taken from Dennis's paper and placed in a separate class. It will be remembered that this paper of Dennis dealt with compound fractures as well as with those of long standing. I am indebted to Dr. Hobart E. Warren, of Denver, for his careful compilation of these tables, which are as follows:

TABLE I.

Cases from Dennis's Table.

Name.	Number of Cases.	Satisfactory Result.	Marked Stiffness and Disability.	Complete Ankylosis.	Amputation.	Deaths.
Beauregard . . .	1	1				
Bernays	1	1				
Bloxam	3	3				
Bryant	1	1				
Bull	2	2				
Cameron	2	1	1			
Coley	1	1				
Dennis	5	4				1 delirium tremens and Bright's disease
Finke	1	1				
Fluhrer	1	1				
Fowler.	1					1 carbolic acid poisoning.
Hardie	4	4				
Hinton	1	1				
Jessop	2	2				
Katzenmeyer . .	2	2				
Keyes	1	1				
König	3		3			
Lammiman . . .	1	1				
Langenbeck . .	1					1 pyæmia.
Langenbuch . .	1	1				
Lauenstein . . .	1	1				
Lediard	1	1				
Lister	5	5				
Lynch	2	2				
Macewen	2	2				
McBurney . . .	1	1				
Phelps	3	3				
Pozzi	1		1			
Ranke	1		1			
Rivington . . .	1	1				
Rose	3	2	1			
Rosenbach . . .	2	2				
Schede	1			1		
Schneider . . .	1	1				
Smith, J.	1		1			
Smith, S. . . .	3	3				
Socin	1	1				
Timme	1	1				
Trendelenburg .	1	1				
Van der Meulin .	3	3				
Wahl	1	1				
Walsh	1	1				
Wright	2	2				
Wyeth	1				1	
Total . .	75	62, or	8, or	1	1	3, or
Percentage . .		82%	10%			4%

TABLE II.

CASES PERSONALLY COMMUNICATED TO THE AUTHOR.

Name.	Number of Cases.	Form of Operation.	Satisfactory Result.	Marked Stiffness and Disability.	Cause of Death.
Abbe . . .	3	Open arthrotomy.	3		
Barton . . .	2	"	2		
Briddon . .	2	"	2		
Bontecou . .	3	"	2		1 sepsis.
Bryant . . .	18	"	17		1 delirium tremens.
Burrell . . .	3	"	3		
Carmalt . .	4	"	4		
Czerny . . .	2	"		2	
Carson . . .	1	"		1	
Davis . . .	6	"	6		
Dennis . .	25	"	25		
Fluhrer . . .	30	"	30		
Fowler . . .	37	"	30	7	
Gallaudet . .	7	"	6	1	
Gerster . . .	3	"	3		
Gussenbauer	4	"	4		
Halsted . .	15	"	15		
Hartley . .	27	"	23	4	
Homans . .	2	"	2		
Horwitz . .	3	"	3		
	5	Barker's	5		
Kocher . . .	24	Open arthrotomy.	22	1	1 sepsis.
Lane	3	"	3		
McCosh . .	2	"	2		
Moore . . .	5	"	5		
Owens . . .	6	"	5		1 both patellæ operated; multiple injuries. Patient did not die because of suppuration in knee-joint.
Park	10	"	10		
Phelps . . .	101	"	95	6	
Pilcher . . .	15	"	15		
Porter . . .	7	"	7		
Stimson [1] . .	70	"	70		
Tiffany . . .	4	"	4		
Van Arsdale	1	"	1		
Warren . . .	3	"	3		
Watson . . .	2	"	2		
White . . .	15	Barker's	15		
Woolsey . .	4	Open arthrotomy.	4		
Total . . .	474		448, or	22, or	4, or
Percentage			94%	4%	.84%

[1] I judge some of those to have been done by the peripatellar suture.—AUTHOR.

TABLE III.—CASES GATHERED FROM LITERATURE

Name.	References.
Butlin	St. Bart. Hosp. Jour., 1887.
Kesteven	Lancet, 1887, Vol. ii, p. 259.
Macewen	ANNALS OF SURGERY, 1887, Vol. v, p. 177.
Rhoades	Med. Press and Circular, 1887, Vol. ii, p. 371.
Ranneft	Nederl. Tijdschr. v. Geneesk., 1887.
Bloxam	Lancet, 1888, Vol. i, p. 621.
Buchanan	Med. and Surg. Reporter, 1888, Vol. lix, p. 399.
Ceci	Deuts. Zeits. f. Chir., Bd. xxviii. p. 245; Centr. f. Chir., 1888, p. 464.
Pochhammer	Deuts. Militärarztes Zeits., 1888. Vol. xviii, p. 442.
Wight, J. S.	Brooklyn Medical Journ., 1888, Vol. i, p. 112.
Armstrong	New York Med. Journ., 1889, Vol. l, p. 174.
Beck	St. Petersburg Med. Wochens., 1889, p. 48.
Fridge	New Orleans Med. Journ., 1889–90, N. S., xvii, p. 102.
Leahy	New Zealand Med. Journ., 1889–90, Vol. iii, p. 162.
Parkes	Archiv f. klin. Chir., 1889, p. 447.
Poland	Lancet, 1889, Vol. ii, p. 1230.
Pickering	British Med. Journ., 1889, Vol. i, p. 410.
Tachard	Bull. et Mém. de la Soc. de Chir. de Paris, Vol. xv, p. 371.
Macewen	Pilcher: ANNALS OF SURGERY, 1890, Vol. xii, p. 400.
Smith, S.	Idem.
Stankiewicz	Przeglad lekarski, 1890, No. 5; Centr. f. Chir., 1890, p. 23.
Cæsari	Gazzo d. ospit., 1891, Vol. xvi, p. 633; Centr. f. Chir., 1892, p. 72.
Croft	Lancet, 1891, Vol. ii, p. 177.
Monod	Bull. et Mém. de la Soc. de Chir. de Paris, Vol. xvii, p. 798.
Reclus	Idem, p. 706.
Barker	British Med. Journ., 1892, Vol. i, p. 425.
Gibb	Idem, Vol. ii, p. 791.
Berger	Bull. et Mém. de la Soc. de Chir. de Paris, Vol. xviii, p. 563.
Page, H. W.	Trans. Clin. Soc. London, 1892, Vol. xxvi, p, 224.
Müller { Schönborn / Mikulicz	Inaug Disser., Königsberg, 1889; Centr. f. Chir., 1892, p. 414.
Velo	Rif. Med., 1892, Vol. iv, p. 74.
Cowell	Clin. Journ., London, 1893–94, Vol. iii, p. 394.
Ballance	Trans. Med. Soc. London, 1894, Vol. xvii, p. 341.
Mahr	Inaug. Disser., Munich, 1894, Centr. f. Chir., 1894, p. 989.
Cant	Quar. Med. Journ., Sheffield, 1895–96, Vol. iv, p. 42.
Trendelenburg	Beiträge zur klin. Chir., Vol. xii, Centr. f. Chir., 1895.
Lenger	Cf. Mon. A. Crickx.
Crickx, A.	Monograph, Le Massage et la Suture osseuse dans les Fractures de la Rotule, 1896, Bruxelles.
Desguin	Idem.
Gallet	Idem.
Lavisé	Idem.
Van Engelen	Idem.
Cook	Clin. Journ., London, 1896–97, Vol. ix, p. 263.
Lejars	Presse Méd., March 30, 1897.
Lucas-Championnière	Journ. de Méd. et de Chir., June 25, 1897.
Marsh (St. Barth. Hosp.)	British Med. Journ., 1898, Vol. i, p. 613.
Riedel	Quoted by Fowler.
Total	
Percentage	

SINCE THE PUBLICATION OF DENNIS'S TABLE.

Number of Cases	Form of Operation.	Satisfactory Result.	Marked Stiffness and Disability.	Complete Ankylosis.	Death.
4	Open arthrotomy.	4			
1	"	1			
1	"		1		
3	"	3			
1	"	1			
1	"	1			
1	"	1			
5	"	5			
2	"	1			
2	"	2			
1	"	1			
3	"		3		
1	"	1			
2	"	2			
1	"	1			
1	"	1			
1	"	1			
1	"	1			
8	"	8			
8	"	8			
4	"	4			
1	"	1			
2	"	2			
1	"	1			
1	"	1			
5	Barker's method.	5			
1	"	1			
1	Open arthrotomy.	1			
1	Barker's method.	1			
13	Open arthrotomy.	13			
1	"	1			
5	Butcher's method.	4		1	
6	Open arthrotomy.	6			
1	"				1 pulmonary embolism due to thrombosis of femoral vein.
3	"	3			
20	"	19		1	
23	"	23			
4	"	4			
6	"	4	1		1 tuberculosis of knee-joint.
1	"				1 delirium tremens.
4	"	3	1		
1	"	1			
1	Barker's method (cerclage).	1			
6	Open arthrotomy.	6			
49	"	47			2, 1 chloroform; 1 gout and uncontrollable vomiting.
28	"	28			
1	"				1 chloroform.
237		223, or 94%	6, or 2%	2, or 1%	6, or 2½%

TABLE IV.—Summary of Operations for Recent, Simple Fracture of the Patella.

Source.	Total Number of Cases.	Satisfactory Result.	Marked Stiffness and Disability.	Total Ankylosis.	Amputation	Death.	Deaths from Sepsis.
I. Dennis's table, New York Medical Journal, April 3, 1886.[1]	75	62, or 82%	8, or 10%	1, or 1%	1, or 1%	3, or 4%	1 from sepsis.
II. Cases personally communicated to the author.	474	448, or 94%	22, or 4%			4, or .84%	3 from sepsis.
III. Cases gathered from literature since the publication of Dennis's table.	237	223, or 64%	6, or 2½%	2, or 1%		6, or 2½%	None from sepsis.
IV. Classes II and III combined	711	671, or 94%	28, or 3%	2, or 1%		10, or 1.4%	3 from sepsis.

As the summary shows, the mortality in the personally communicated cases has been four out of 474, or a little less than 1 per cent., while of the cases gathered from literature six out of 237 died, or 2½ per cent. If we add the figures, we have a total of 711 with ten fatal cases; three succumbed to sepsis, while the remainder died from other causes.

This mortality of 1.4 per cent., when contrasted with the 4 per cent. of deaths in Dennis's table, shows a definite decrease in the ratio during these later years. If, now, we analyze these deaths from sepsis, we find that both Kocher's and Bontecou's were in the earlier years, while Owens's was in a case of fracture of both patellæ, the patient having sustained added injuries. Certainly, so far as sepsis goes, this record of three deaths and no amputations out of 711 cases seems to indicate that the operation is a safe one; but the question may well be asked whether this represents the true mortality. I must admit that I do not believe that it does. I have trustworthy knowledge of three deaths from sepsis following this operation during the past year, each in the practice of a skilled surgeon, and each in a well-equipped and modern hospital. I am further obliged to add that I am

[1] The remainder of the 187 cases collected by Dennis were operations for compound fracture or fracture of long standing.

acquainted with one case of amputation for septic arthritis, this following an operation done by a house officer in one of the larger hospitals of our country, but I also know of a considerable number of cases in which the result was in all ways excellent. So that my estimate of the mortality would be that at most it is less than 2 per cent., and that the deaths from sepsis would be rather less than one in 100 of all operations.

Of the general results more will be said in detail a little later; but it may not be amiss to call your attention at this time to the fact that of the total number of cases but 3 per cent. came out with marked stiffness and disability, and something less than one-half of 1 per cent. with complete ankylosis.

Limitations attending the Operation: Selection of Cases.— As one reads the personal opinions cited in the foregoing pages he is struck by the number who emphasize the fact that only surgeons of, if I may use the term, exceptional judgment and skill, working amid the most perfectly controlled surroundings, equipped with all that goes to make complete asepsis, and with the aid of carefully trained assistants should undertake this operation. It is one which entails exceptional responsibility on the operator. It is done for a condition which does not threaten life and in which non-operative methods give fairly satisfactory results. It therefore devolves upon him to select his cases with the utmost care and to surround himself with all possible resources. Patients submitted to this operation should be of a suitable age, let us say under fifty-five years, and should have healthy viscera. This is imperative. In general, one may say that those who are obliged to pursue arduous occupations, occupations which necessitate much standing or walking, may be subjected to operation more readily than those who are not dependent on good knees for a livelihood. Fracture of both patellæ is, I think, a decided indication for operation. Further, the amount of separation between the fragments may guide one in deciding to operate; in general, it may be said that if they can be

brought within one centimetre of each other operation is contraindicated. In all cases the matter should be submitted to the patient and explained to him as thoroughly as may be.

Time of Operation.—Operators differ in this, Fluhrer and others would operate immediately after the receipt of the injury, while Fowler strenuously advises waiting until the acute symptoms have subsided. The latter correctly says that contusion of the tissues about the joint diminishes their vitality, and that in such instance a little sepsis may spread with great rapidity. The same view is taken by Beale (*Treatment*, January 27, 1898), who says that operation should be performed immediately after the fracture has occurred only when the two following conditions can be observed together,—namely, that blood has not begun to be effused and that no direct violence has been done to the part. There is no doubt that a few septic organisms do occasionally gain access to our wounds, but they are so few that their destroyers are able to cope with them. They will almost certainly overcome them in healthy tissue, but they may not be able to do so in tissue whose vitality is impaired and which is the seat of early inflammatory changes.

Whatever the time adopted for the operation previous sterilization of the operative field should be most thorough, and it must be remembered that in many cases this is very difficult. The skin over the knees of laborers, especially those who follow such occupations as carpet-laying, scrubbing floors, shoemaking, etc., is apt to be thick and rough and creviced; the cleansing of it should be scrupulously cared for.

Operative Procedures.—Aside from the mechanical aids to close apposition of the fragments, Malgaigne's hooks, the steel rivets of Kittredge, Bruns, and Schumpert, the various methods (Robson, Marshall, Anderson, Myles) of passing pins through the tendon of the quadriceps and the ligamentum patellæ, or the fragments themselves, while endeavoring to avoid opening the joint, none of which have met with much favor, we have two principal methods of operation.

The first, which may be termed the procedure of Lister,

boldly opens the joint, empties it of clots, and sutures the rent in the capsule as well as the fragments of the patella. The other is exemplified by the Barker operation, and is a subcutaneous, or rather percutaneous, cerclage of the bone. This latter procedure is described as follows: After aseptic cleansing a tenotome is thrust into and through the ligamentum patellæ in its midline antero-posteriorly and a small cut made. Through this opening an appropriate needle is carried in and up behind the fragments, and made to emerge through the skin just above the upper fragment, the fragments being apposed and steadied. The needle, threaded with stout, aseptic silk, is now withdrawn, leaving the thread behind the bone. It is reintroduced and passed up in front of the fragments and out at the upper hole, threaded and withdrawn below. The fragments are brought well together, friction used to displace clots, etc., the silk ligature tied, and the knot buried. White, of Philadelphia, who has employed this method fifteen times, and who speaks well of it, begins passive motion on the tenth day, gets the patient out of bed wearing a light plaster splint at the end of the third week, and says that good use of the joint may be expected in from eight to ten weeks or earlier. We have but few recorded cases of this operation, but these seem to show no casualties. However, it is well to note that White says (ANNALS OF SURGERY, 1895, Vol. xxii, p. 661) that while none of his cases have had the least after-trouble, he knows of cases in other hands in which septic arthritis has followed this operation and the patients barely escaped with their lives. White's ultimate results were far better than he had obtained by the older methods, and he urges the adoption of Barker's procedure in all cases.

Of similar plan is the method of Ceci (*Deutsche Zeitschrift für Chirurgie*, 1888), who employs a percutaneous suture encircling the fragments; that of Butcher (*British Medical Journal*, 1892, p. 904), which differs but little from Ceci's; Kocher's (since discarded by the Berne surgeon himself), in which the thread was tied over a cushion of rubber or cork in front of the bone; Volkmann, who used a form of cerclage;

Aitken, who drilled the fragments longitudinally and withdrew a thread which he tied subcutaneously.

The peripatellar, percutaneous suture was, I think, extensively used by Stimson, who seems to have given it up in favor of the operation described by him. I fail to see wherein lie its advantages; it certainly exposes the joint to the risk of infection; it cannot deal with the fibrous tissues which, we have seen, are almost always interposed between the fragments; it does not reunite the lateral tears, and it does not clear out the joint clots which are so prone to organize and lead to a low grade of arthritis. If any operation be advisable it would seem that open arthrotomy should be the one selected. Of this there are numerous modifications, but the principle is simply that of free incision, removal of clots and fibrous tissues from the breach, and suture of what needs to be reunited.

It is needless to repeat that the most painstaking asepsis and the aid of competent assistants are imperative. The incision may be the original longitudinal one of Lister, or the transverse cut between the fragments, or a flap turned up from below, as done by Lucas-Championnière, or the U-shaped flap with its attached base below. When the incision is directly in front of the callus a refracture or a rupture of the callus may tear the attached soft parts and so make this second break a compound one. To avoid this some operators have proposed a vertical incision on the side of the patella; but to this latter the objection is made that it may be difficult to deal with the torn aponeurosis of the vastus on the opposite side. The vascular supply to the knee is so free that it is hardly probable that a flap turned up or down will slough, and such incision certainly answers all indications admirably. I have said that it is favored by Lucas-Championnière; he is an ardent advocate of operative procedure, and has paid much attention to the details of the operation itself.

Most operators remove all clots from the joint, either by wiping them out with sterile gauze or by gentle salt irriga-

tion. Antiseptic solutions are uncalled for, a sterile saline solution answers all indications, these being, indeed, simply mechanical. Some writers lay stress on not disturbing the blood, but I fail to see why their advice should be followed. Risk of sepsis is certainly less when the joint is empty, and we have all reason for thinking that the blood organizes and forms adhesions. The prepatellar tissues which have fallen into the breach are to be carefully trimmed away, the fractured surfaces may be cleansed of clots and, if need be, freshened. The lateral tears are to be accurately sutured, preferably with catgut.

As to uniting the bony fragments themselves a multitude of ways have been set forth. They may be drilled and joined with absorbable or non-absorbable sutures. A single thread may be used, or one on each side. The holes in the fragments may go through the posterior surface of the bone or they may stop just in front of it. Some operators of wide experience content themselves with suturing the soft parts at the front of the fragments. If silver wire be used (and this, from its tensile strength, seems the best of the non-absorbable sutures), it may be tightly twisted, and the ends hammered down in the crevice between the fragments. Silkworm gut has been used. Heavy, chromicized catgut or kangaroo tendon make an excellent suture when one is sure of their sterility. Fowler applies hooks devised by him, these to be removed at an appropriate time. Lejars (*Presse Médicale*, 1897, p. 125) uses cerclage when one of the fragments is very small or when comminution is present. The wire is passed through the tendon of the quadriceps close to the upper fragment and equidistant between its anterior and posterior faces; then it surrounds the fragments going close to the bone through the ligamentum below. Berger (*Gazette Médicale de Paris*, 1897, p. 306) and others speak well of this cerclage. It is, as Lucas-Championnière says, simply a modification of the operation of arthrotomy and osseous suture. When it is employed the soft parts in front are sutured with catgut.

Comminuted fragments are to be left or removed ac-

cording to the judgment of the operator. Inability to approximate the fragments is exceedingly rare in these operations for recent fractures, but it may necessitate scoring or division of the quadriceps muscle or its tendon, as has recently been done with marked success by Wyeth and Erdman in cases of long standing, or transplantation of the tubercle of the tibia as cleverly carried out by Keen.

Employment or absence of drainage will also depend on the individual judgment of the operator. Drainage has two excuses,—imperfect hæmostasis and doubtful asepsis. It seems to me that the surgeon whose resources and methods warrant him in undertaking this operation should be able to dispense with it.

The skin sutures and confining splint may be removed on the eighth or tenth day, but at that time it is best to commence massage and passive as well as active motions. I believe early motion to be highly desirable. It prevents adhesions, the massage preserves the quadriceps. At the end of the third week the patient may be up and about; he should wear a check apparatus until the joint has such free flexion that danger of refracture is practically gone. This will be, perhaps, at the end of the third month, but he should have resumed active life much before this. It is well for us to remember that almost all of the refractures take place during the first year. We see, then, that this operative management is not purely operative, but rather synergistic; a combination of open suture and massage.

Immediate and Remote Results of Operative Management, and Comparison of these Results with those attained without Operation.—So far as the immediate results are concerned there is but little difficulty in arriving at an opinion. We have seen wherein lies the danger to life and limb, and we learn from the tables which I lay before you that at the time of discharge 94 per cent. of 711 operated cases were in a satisfactory condition. I have already referred to the fact that so many reported cases were operative results, but that they did not permit of judgment as to end results. For this reason

I placed the table marked "Satisfactory" at the head of the list rather than one marked "Perfect," for the number which could be accurately grouped under the latter caption would be misleading. So far as immediate results go I question whether operation offers much of a gain over the Dutch massage method. By either form of treatment the patients resume daily life much earlier than when treated by the older methods. In the personally communicated opinions set forth in the foregoing pages it will readily be seen that the consensus of opinion goes to show that operation saves a goodly amount of time to the patient when compared with confinement measures.

But in the ultimate history of the limb the condition of the callus plays a most important part. A fibrous callus tends to stretch and ultimately to break, and while I have thought it best to discard the term bony union, the history of these cases goes to show that if the union be so complete as to render independent mobility of the fragments impossible, it is improbable that it will become incomplete or such as to allow of their mobility.

That osseous suture gives by far the greatest percentage of complete union is evident, and, further, I am convinced that it gives the smallest percentage of refractures, a matter of no small importance. This matter of refracture has been carefully studied by Bégouin and Audérodias (*Gazette Médicale de Paris*, 1897, p. 505), who cite thirty cases from Ham ("En nadeclen van de Behand," etc., Amsterdam, 1893) and add five personal cases, each of the thirty-five treated by massage and followed for a sufficient length of time. In 8 or 22 per cent. there was subsequent rupture of the callus. In a complete search of literature these authors find but seven iterative fractures after operation. (Reported by Peyrot, Lucas-Championnière, Mounod, Mayo-Robson, Stimson, and themselves.) While this number of cases is far too small to permit of conclusions, it is a fact that the closer the union the less is the danger of refracture, and it must be seen that

reuniting the vasti relieves a certain amount of the strain brought to bear on the quadriceps tendon.

Stumpff ("Inaugural Dissertation," Berlin, 1894) analyzed twenty-eight cases of refracture, and found that in seventeen the callus gave way, in seven the bone was fractured anew, in two the tendon parted. Crickx found in thirty-one cases treated by massage 25 per cent. of refractures, and in 249 cases (from Hamilton, Bull, Le Coin, Howe, Ham) managed by the older confinement methods 13 per cent. of refractures. He therefore concludes that massage gives a greater percentage than any other method, but his conclusions seem to me hasty and based on too few of the massage cases. Surgeons who have performed a considerable number of these patella operations emphasize the rarity of refracture, yet we still need large series of cases followed for a sufficient length of time. Until we get this our conclusions will be mainly inferential.

And inferential as well must be our conclusions regarding ultimate results. While Halsted, Abbe, and others place all of their results under the head of "perfect," most of the observers have lost sight of their cases at the end of the second or third month. I have therefore used the term "satisfactory" as embracing all cases in which the result was better than moderate stiffness and disability. The word "excellent" might be used here, I think, in the sense in which Bull used it. Of the 711 cases definitely reported the result is placed as "satisfactory" in 94 per cent. I should like to get nearer to accuracy in this important matter, but it is impossible to do this until the cases are reported after the lapse of at least a year, while two years would be a better limit.

We are not to overlook the fact that there are practically no arguments against operative procedure on the part of those who have accorded it a fair trial, and this must be taken into consideration in weighing such a matter. Rose, of London, writing in the "Year-Book of Treatment for 1898," says: "The open treatment of fractured patella is still looked upon askance by many, but it is gaining ground as the most certain

means of securing perfect apposition and union of the fragments." This, I am inclined to think, expresses the matter pretty clearly.

My own opinion in this matter is made after a study of the literature and the personal communications embodied in this paper, for I have never operated on a recent, simple fracture of the patella, and, indeed, began the study of the subject with something of a prejudice against operation.

That the procedure has a well-fixed place in surgery seems plain. I believe it should be done only by adepts in surgical art; that it should be confined to healthy individuals of suitable age; that its dangers and advantages should always be fully explained to the patient; that it should be reserved for fractures presenting a diastasis of over one-half of an inch or with extensive lateral tears of the capsule,[1] and that it should always be supplemented by early massage and mobilization of the joint. The preferable form of operation is open arthrotomy. The suture of the soft parts should always be carefully made; such suture may be applied to the bone as the operator's judgment may dictate. Such cases as are not suitable for operation may best be managed by the Dutch massage method, and this form of treatment may well be adopted by the general practitioner who thinks it inadvisable to undertake operative measures.

[1] Wicky says that these lateral tears are easy of recognition from the joint-distention and bulging.